Pixel Module Presentations

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September 1999

Bump Bonding

- Have been following work by BTeV and US CMS.
- AIT(Hong Kong)
  - Indium
  - Wafer level defect rate comparable to IZM/Alenia
  - Multiple single chip assemblies with good quality
  - X-ray capability demonstrated
- MCNC(US)
  - Solder
  - Joint BTeV/US CMS substantial contract in place for dummy 6” wafers
  - First results in about 3 months
  - Difficulty with 4” wafers?
- Focus Interconnect(US)
  - Claim to be capable but no ongoing work yet.
- ChipBond(Taiwan)
  - Contacted. Not clear if interested or capable yet.

Recent X-Ray

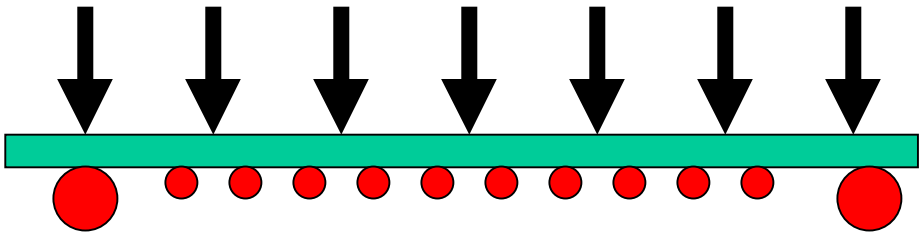
- X-rayed two recent IZM modules. Look good. Good to perfect agreement with IZM X-Ray.
- X-rayed one Alenia module. Perfect or nearly so.

IC Wafer Thinning

- Our nominal specification is 150 microns thick. This is a challenge.
- Reminder of ancient history
  - One-half of Boeing indium bumped FE-B wafer(protected by photoresist) was successfully thinned and diced by GDSI (http://www.wafergrind.com/index.html) to 150 microns.
  - Boeing subsequently successfully assembled(although considerable merged bumps) a 16-chip module with these die.
  - GDSI also successfully thinned a few 4”, dummy wafers from Alenia with indium bumps(no photoresist) to 150 microns but these were damaged by them and by me in packaging. This is easily avoided.

Recent Wafer Thinning

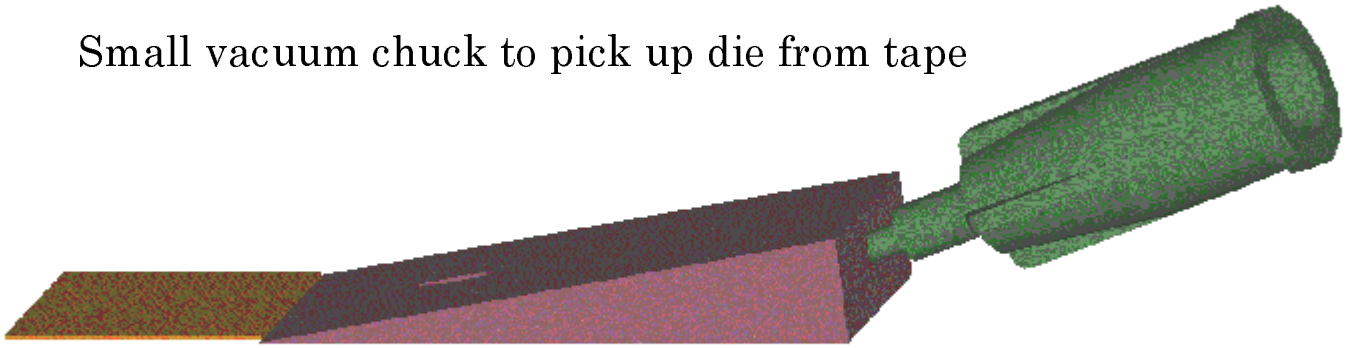
- Dummy 6” wafers from IZM were tried at GDSI, Okamoto (http://www.okamoto-sed.com/products/tps-e.html) and TruSi Technology (http://supersites.net/trusi). GDSI and Okamoto use standard grinding techniques. TruSi is a new company with a new atmospheric plasma etching process that is aimed at the very thin smart card market(50 - 300 microns).
- Results
  - GDSI - shattered wafer
  - Okamoto - broke wafer into two pieces
  - TruSi- it worked but this is a relatively high temperature process, hard to go below 160^0 C.
- However, dummy wafers from IZM were of very poor quality. No photoresist protection. Metal build up at edge of wafer. Wafer is held by UV-releasing tape. This partially compensates for uneven height but not enough. As wafer thins, is “edge supported” and breaks.



More Recent Wafer Thinning

- Alenia bumped FE-B wafer was successfully thinned to about 150 microns by Okamoto and diced(badly) by Micro Dicing(although they have diced these wafers before, cut through all “a” chips). This wafer had a thin photoresist coating, not a thick one (bumps stick out).
- It’s a tedious process to take 150 micron thick die off dicing tape, wash to remove photoresist and package. We developed a bit of special tooling to do this but even more will be needed if this is to be done in production mode.

Small vacuum chuck to pick up die from tape



Wafer Thinning Lessons and Plans

- IZM is fabricating additional,and better dummy wafers to try thinning and we should do a real FE-B wafer(the one planned was lost in the mail at LBL!).
- For solder, we should try with and without photoresist protection. Photoresist is also useful to protect from small chips during dicing, which get washed away. But washing is a pain.
- For indium, I think photoresist is required but really should do this also with and without.
- We still have not demonstrated if solder bumping works at all for thinned die. Concern is warpage over die preventing contact.
- My guess(and only a guess) is that 150 microns is feasible but will require very careful work at every step of handling die. This will add to the manpower required and time.

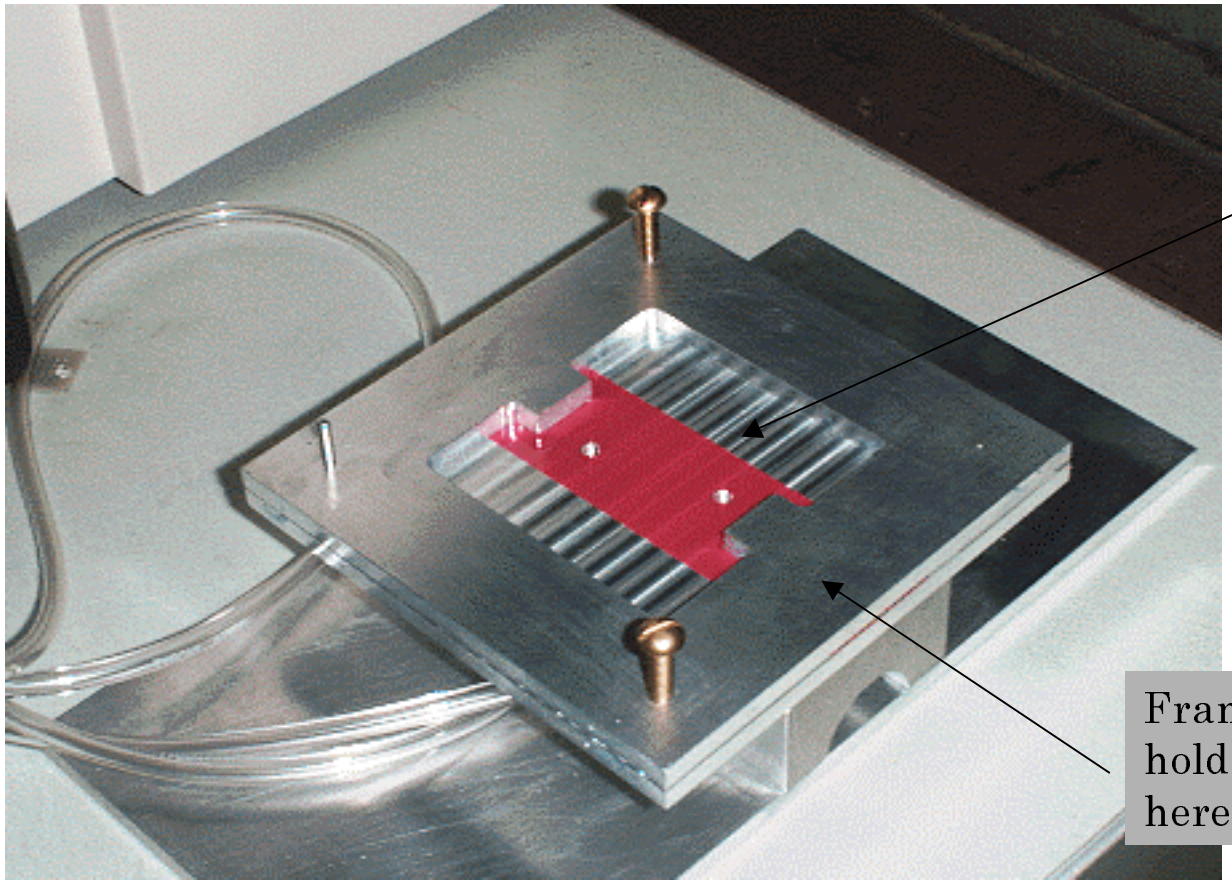
Thinning and Dicing Companies

- There is a strong concentration of thinning and dicing companies in the Bay Area(Silicon Valley).
- GDSI, Okamoto, TruSi and another thinning company, Aptek (http://www.aptekindustries.com/welcome.htm) are all within a few miles of each other.
- GDSI does dicing and the others have connections to or recommended companies for dicing or there are other dicing companies with whom we have experience(LBNL has standing contracts with two dicing firms).
- Draft Market Survey completed for thinning.

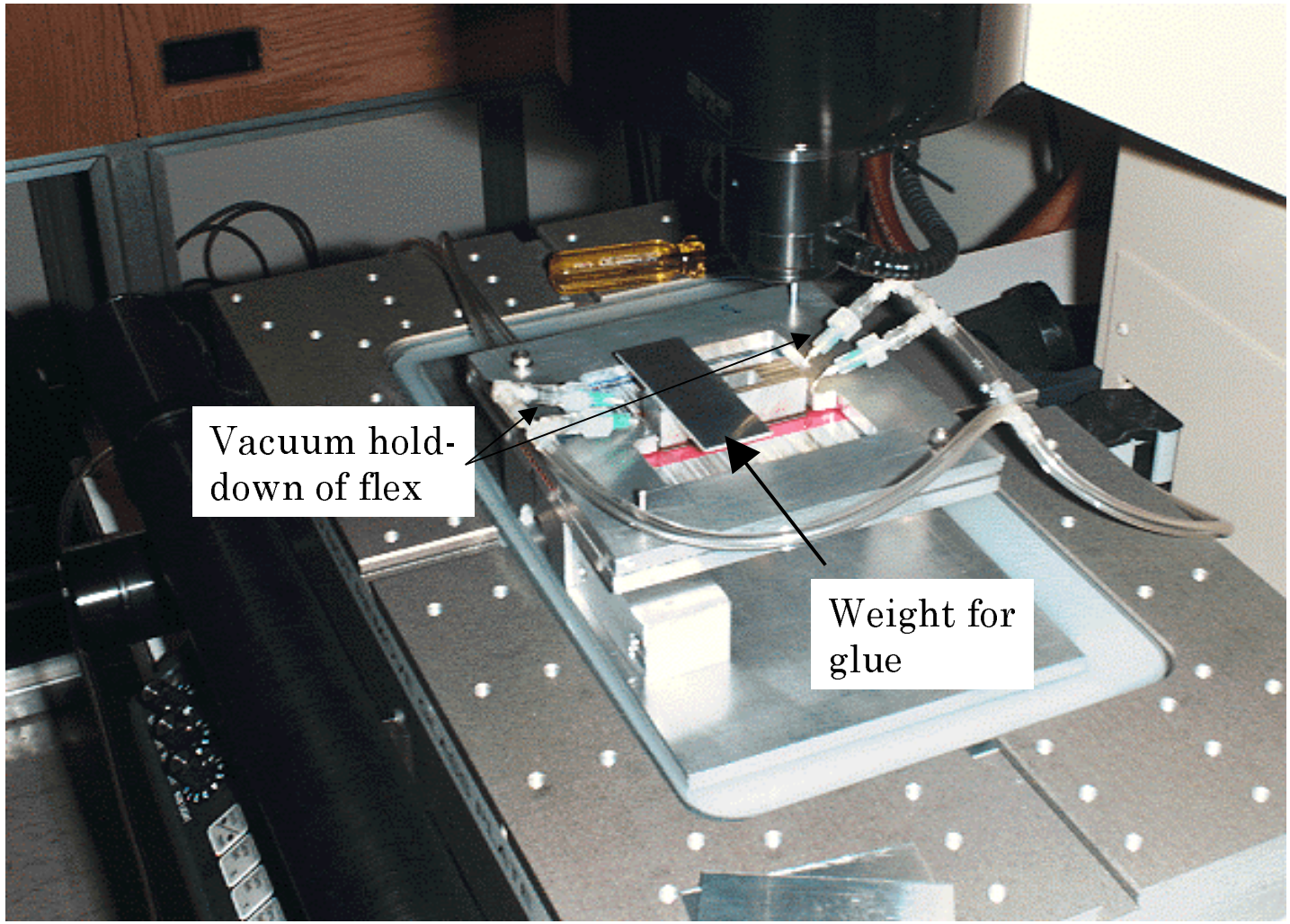
Module Assembly Status

- I'm reporting on the work of mostly Fred Goozen at LBL. See his Web Pages http://pxs.lbl.gov/~goozen/INDEX.html
- Two efforts
  - Assemble a few modules fast for test beam
  - Develop tooling and procedures aimed at production
- For the few modules, simple tooling, hand alignment but easy to modify -> learn
- Aimed at production, more detailed tooling, precision alignment via pins and jigs, alignment marks, study survey….explore the whole process.
- Thermal, mechanical and wire bonding tests….

Simple Tooling

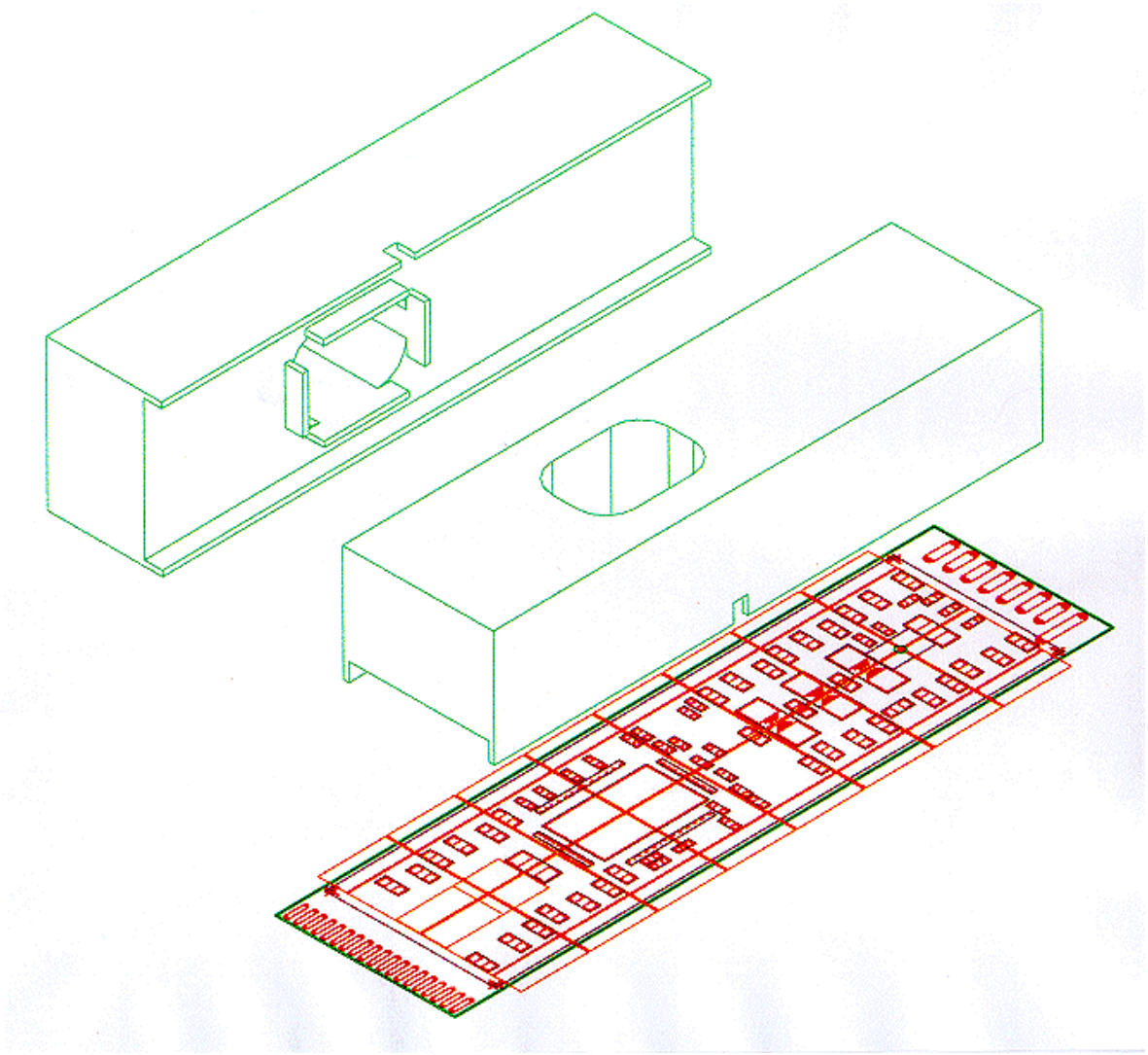


Simple Tooling



Module under SmartScope for alignment by hand. Use wire bond pads to align along with edges.

Simple Tooling - Weight



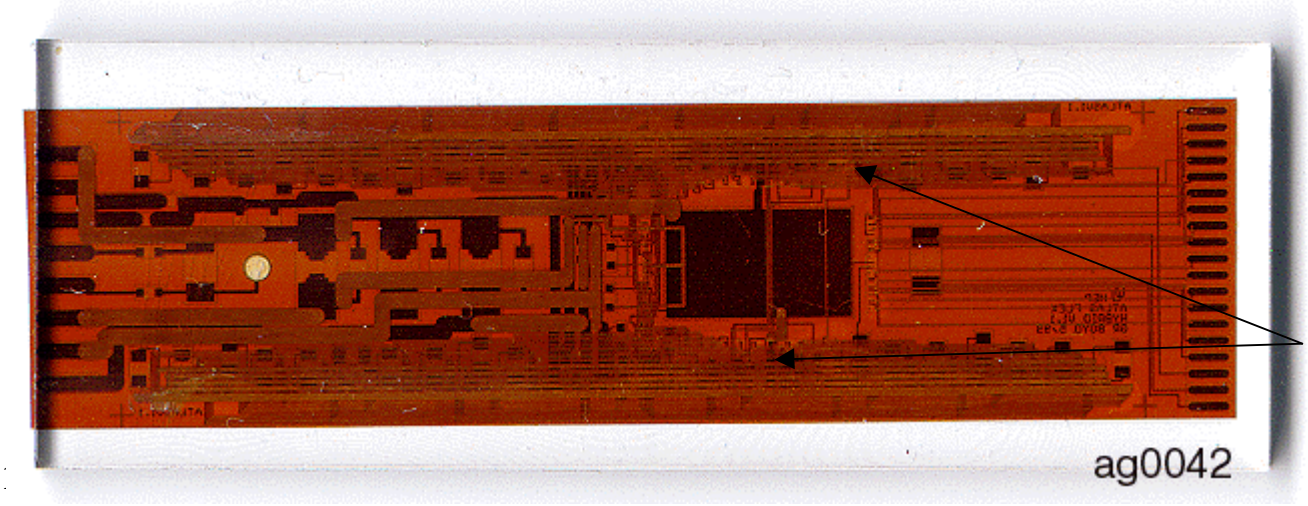
Adhesives for Attaching Flex

- Few previous modules had flex attached with Thermagon thermally conducting phase change material. See http://www.thermagon.com/tpcm900.pdf for properties. Although this worked, this a film adhesive and some bubbles remained, making wire bonding not so easy in spots. It's also thick. So we wanted to move to a more rigid material.
- Initial attempt with latest modules used Araldite 2011, which has been characterized by the SCT groups. Properties and measurements may be found (at least) at

  http://www.cibapolymers.thomasregister.com/olc/cibapolymers/twoepoxy.htm

  http://hepunx.rl.ac.uk/atlasuk/sct/moduleAssembly/generalInfo.html

  http://www.hll.mpe-garching.mpg.de/~lca/glue/gluetest.html
- Flex on first module assembled with Araldite was bad. Tried to remove. Broke module.
- Second module was assembled with Thermagon to allow removal of flex.



Flex on Lexan

About 25μ of Araldite

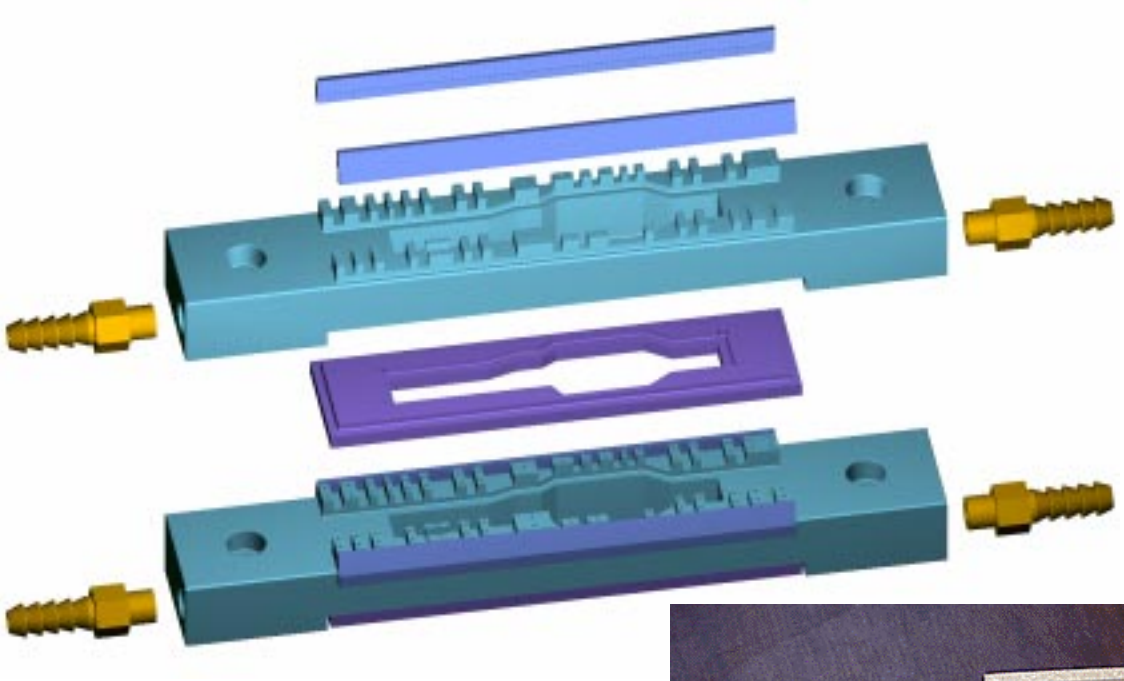
Lessons from Assembling Recent Module

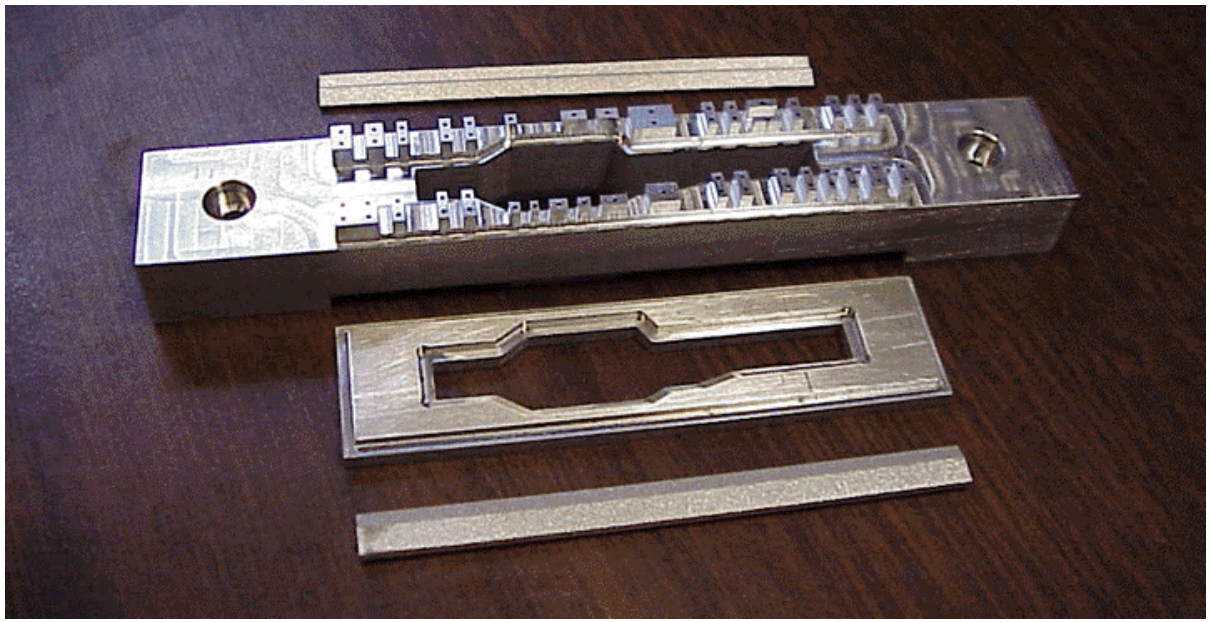
- Assuming this is done….what were problem relevant to next time….from Fred, Kevin

Looking Toward Production

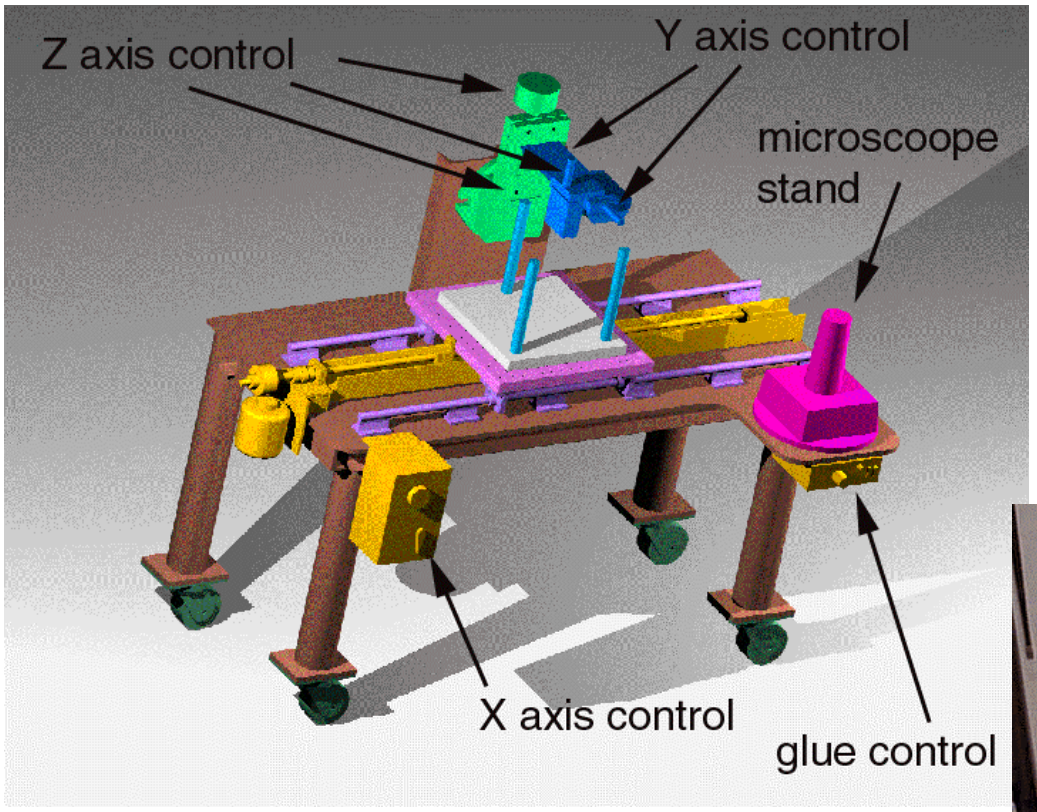
- Perhaps we can continue to use frame to hold flex for attachment and it's clear how to improve this.
- However, we have also designed and built a custom vacuum chuck to hold flex (and probably later module) - see next page.
- We have also designed a custom "glue dispensing" precision table and system and are assembling this now - see next, next page.
- We plan to use defective flex hybrids and have cut industrial grade silicon wafers to the correct dimensions. We will use these + glass/Lexan slides to practice dispensing of glue, alignment, pick up…..practice.

Custom Vacuum Chuck





Glue Dispensing Table



This is planned for dispensing glue for flex attachment and may also be used for dispensing adhesive to attach modules to sectors.

Most components exist and under assembly to start trials in October.

Plans

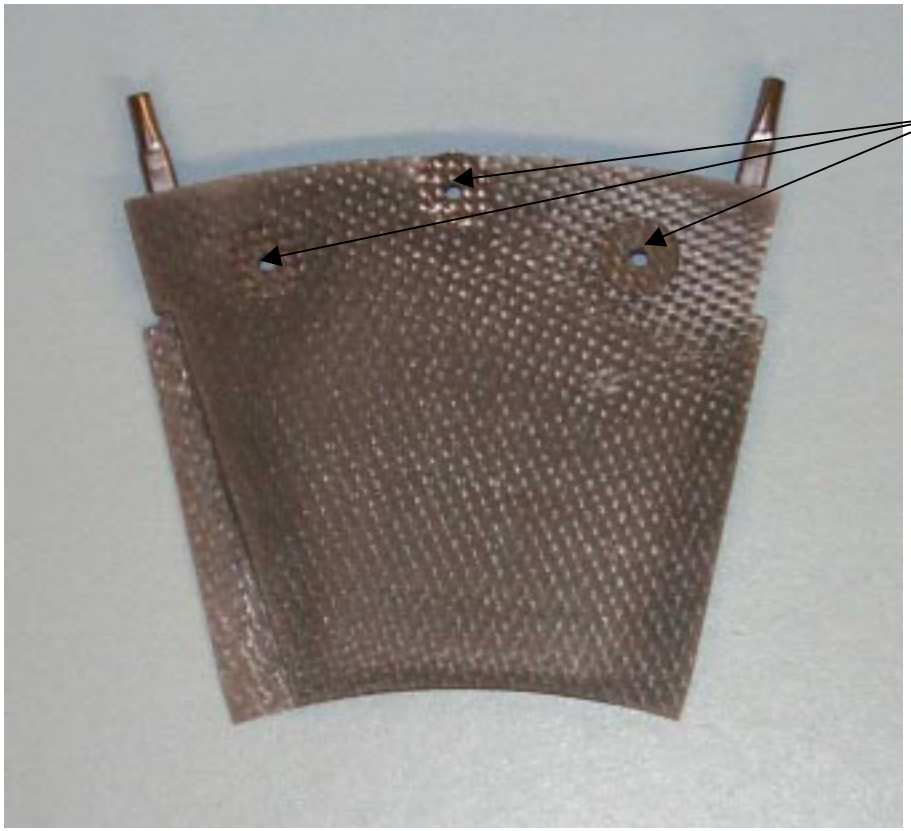
- Glue flex to silicon/sensor
  - Practice gluing
  - Measure deflection coming from CTE mismatch as cooled.
  - Compare with FEA model(to be done by Eric)
  - Implications depend on results. Worst case, mismatch causes delaminating force for bump bonds => either glue down flex to support structure(easy in the disks, hard in the barrel) or underfill. NOT CLEAR A PROBLEM EXISTS.
  - Thermal cycling tests, peel tests,…..reliability of glue joint.
  - Use same structures(but need decent flex) as vehicles for wire bonding tests, including with automated bonder
  - Practice with and without components on flex, including MCC.
  - Some of this has started and hope for significant results by December meetings.

Module Attachment Status

- We have started the work on tooling and procedures for attachment of modules to disk sectors. This is at early stage.
- There are two ways to approach this
  (1) Place module using FE die edges as reference and then survey precisely using optical measurement system relative to targets on the sector.
  (2) Place module using alignment marks on sensor/die via optical system and then survey precisely using optical measurement system relative to targets on the sector.
- We will try (1) first since it's much easier and cheaper and if this does not give sufficient placement precision, fall back on (2) if needed.
- There are a number of common items in either approach.

Sector Reference and Targets

- The concept is to place the module relative to mounting points on the sector. The mounting points are referenced by attachment to the disk support ring, and this ring to the frame



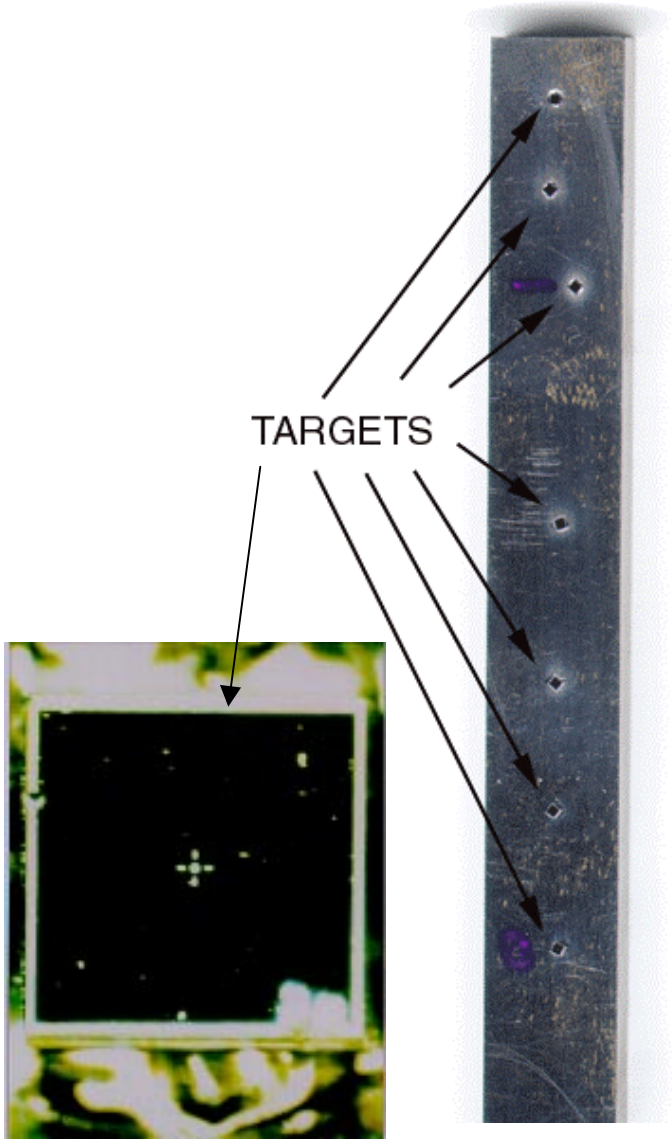
These mounting holes determine the reference system for mounting modules to a sector.

Mount alignment targets(see next page) as needed on the sector to make measurements easier.

Reference these targets to the mounting holes as part of the sector assembly and QC process.

Targets for Optical Measurements

- We have made 2 4”, 300 micron thick silicon wafers at LBNL with 1 mm x 1mm pieces containing targets for optical measurements.
- These targets are similar to those on the sensors and FE die.
- Glue these where you want them
- Quick measurements on flat plate indicate out-of-plane accuracy of our optical measurement system to be about 7 microns rms with these targets. In plane accuracy is harder to measure but is expected to be 2-3 microns rms.
- Can program the optical measurement device to make multiple measurements at single point, average, dump data into tables, etc.



Module Attachment Concept

- Sector is mounted in precision jig using mounting holes. Targets on sector have been premeasured relative to mounting holes.
- Dispense adhesive
  - either via stencil referenced by pins to the sector(we will try this)
  - or using precision gluing table
  - will try first with CGL7018
  - remove stencil if used.
- Use precision alignment fixture pinned to precision jig to locate module by edge reference.
- Pick up module with vacuum chuck
- Put module in fixture, edge reference and weight appropriately.
- Repeat for other two modules on sector side #1.
- Survey with optical measurement system(likely do this for each module at first). This will measure alignment marks on sensor and on FE die relative to targets on sector.
- Cure CGL and UV tack
- Flip over and repeat steps.
- Do final optical survey of both sides(again) and record in database.

Module Attachment Prototype Plan

- Jigs and fixtures under design now.
- Will use dummy silicon pieces(with targets) on sector mockups(real carbon-carbon faceplates)
- In parallel, are making measurements to understand absolute accuracy and repeatability of different dicing vendors. This will take time, since accuracy within a single dicing lot tends to be very good(few microns) but the issue is lot-to-lot variation. And some vendors are better than others.
- And in parallel expect to evaluate using track simulation code(Vacavant) effect of placement accuracy.
- If this concept works, refine tooling etc.
- If placement accuracy is insufficient, build in fine adjustment to fixture and place under optical system(this likely requires purchasing second such system - not cheap).